Resource Action: EWG-13A and 20 **Task Force Recommendation Category: 1**

Proposed Large Woody Debris Placement in the Low Flow Channel and the Lower Feather River

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Description of Potential Resource Action:
This Resource Action consists of a proposal to place large woody debris (LWD) in the Feather River. The intention is to improve rearing habitat for anadromous fish, improve geomorphic processes and enhance opportunities for recruitment of riparian vegetation.

There are several other resource actions that are either similar to or otherwise related to this measure:

- EWG-13B, proposed to improve rearing habitat in the low flow reach through placement of wood and other materials.
- EWG-16A and EWG-16B, proposing creation of side channel habitat in the low flow reach.
- EWG-17 and EWG-51, that would enhance riparian vegetation to increase shading and habitat complexity.
- EWG-89, that would involve levee setbacks and increase floodplain accessibility to the river.
- EWG-19A and EWG-22, proposing levee setbacks and/or geomorphic restoration in the lower Feather River to improve connectivity between the river and its floodplain.

Nexus to the Project:
Lake Oroville effectively prevents recruitment of LWD from the upstream reaches of the Feather River and its tributaries to the low flow channel, the lower Feather River, and ultimately, to the Sacramento River Delta. Existing sources of LWD are the riparian zone along the river and incidental inputs from orchards. The primary recruitment mechanisms are bank erosion and disposal of wood by landowners adjacent to the river. The amount of LWD generated from these sources is probably less than would have been recruited prior to construction of Lake Oroville. It is also different in quality since coniferous LWD would have been transported to the lower river from the upper watershed. As a result of the blockage of LWD by the dam, LWD may be limited in abundance and size in the river in at least some locations. Inputs of LWD to the Sacramento River and Delta have probably also been reduced. However, this is not solely due to the dam but is also affected by the flow regime, channel geomorphology and the constraints they exert on downstream transport of LWD from the Feather River.

Potential Environmental Benefits:
LWD contributes to a variety of geomorphic and ecological functions in rivers and streams. For example, woody debris can enhance the complexity of rearing habitat and redirect stream flow to create scour pools that serve as holding habitat for anadromous fishes. LWD can store and organize sediment into geomorphic surfaces where riparian vegetation recruitment can occur. Decaying LWD provides a source of instream nutrients for aquatic organisms. Generally, the influence of LWD on stream geomorphology and ecology varies with stream size (Lassettre and Harris. 2001). On larger streams such as the Feather River the effects of LWD on geomorphic process may be somewhat limited as compared to its effects on smaller streams, but it still performs important ecological functions. Most LWD in larger streams is found on floodplain surfaces and at the periphery of the channel. Individual pieces or aggregations of LWD (i.e., debris jams) are less frequently found in mid-channel locations. Stream scale precludes individual pieces or jams from spanning larger streams. On larger streams LWD can provide shelter for salmonids, especially along banks, and when associated with secondary channels, it can help create rearing habitat.

Potential Constraints:
There are two major constraints that will affect this measure. First, the regulated flow regime and lack of sediment sources will reduce the effectiveness of LWD in shaping and creating habitats. Second, there may be some objections to placement of LWD based on impairment of navigability and potential unforeseen effects on channel behavior (i.e., potential for increasing bank erosion).

In the event that it is desirable to use coniferous LWD for restoration and enhancement, a third constraint on placing wood in the lower Feather River is that sources of coniferous LWD may be limited or at some distance from placement sites.

Comments on a draft of this report pointed out the benefits of placing LWD and other materials on rip-rapped banks or in conjunction with new rip-rap projects. This has been done for new rip-rap projects on the American and Sacramento Rivers. There are no known constraints to doing this on the Feather River.

Existing Conditions in the Proposed Resource Action Implementation Area:

Low Flow Channel: The low flow channel of the Feather River is a regulated stream reach. Flows are nearly always about 600 cubic feet per second (cfs), except when peak runoff events require flood control releases from Lake Oroville. During those events, flows may exceed 100,000 cfs for sustained periods. Flows of this magnitude occurred in 1965, 1986 and 1997.

The low flow channel is generally confined between levees. There are some mid-channel bars, lateral bars and islands which are stable within the current flow regime. The slope gradient in the low flow channel ranges from 0.06% to 0.2%. Flow widths vary from 200-500 feet at normal regulated flows of 600 cfs to 2,500 feet at flood control flows of up to 100,000 cfs. Water velocities range from 1 to 4 feet per second (fps) at 600 cfs to approximately 12 fps at 100,000 cfs.

Riparian vegetation along the low flow channel generally consists of a gallery of mature cottonwoods along the banks and a variety of native and exotic trees, shrubs and herbaceous species both on banks and on islands. Openings available for natural regeneration of riparian species are limited and competition from exotics is extreme. Most existing openings have coarse textured (cobble) substrate, which is unsuitable for regeneration of most native riparian species.

Due to the riparian vegetation composition and distribution, potential on-site LWD contributions to the low flow channel are very limited. The only recruitment mechanism is bank erosion and this is not a major process in the low flow channel.

There is very little formal bank protection in the low flow channel reach. Existing rip-rap is generally confined to protection for highway bridges.

Surveys of LWD in the low flow channel have recently been completed but the data are not yet available. They will show LWD amounts by position (bank, mid-channel, side channel, and backwater) for the low flow channel. Initial impressions indicate that LWD loading in the low flow reach is lower than the loading in the lower Feather River. Also, piece size tends to be smaller in the low flow reach. As a result, there is relatively limited diversity of instream habitat contributed by LWD. The geomorphology of the low flow reach suggests that additions of LWD could have significant benefits.

Upstream sediment delivery to the low flow reach is also blocked by Oroville facilities. No active sediment recruitment or bench formation is presently occurring in the low flow reach. The only source of sediment is bank erosion, which is limited. This is a very minor source in comparison to the amount of sediment trapped by the dam.

The low flow channel is an intensively utilized spawning area for anadromous salmonids. Juvenile salmonid rearing habitat quality and quantity could potentially be improved though increased medium to high complexity LWD availability.

Lower Feather River (below Thermalito): Streamflow in the lower Feather River is mainly determined by releases from Lake Oroville and Thermalito to downstream water users and by inflow from major tributaries (Bear and Yuba Rivers). The streamflow regime is markedly different than a natural streamflow regime. Mean annual streamflow as recorded at gages at Oroville, Gridley, Yuba City and Nicolaus ranges from 4,800 cfs to 8,100 cfs. During the summer months, impaired flow is usually considerably higher than unimpaired flow. Mean monthly impaired flows are less than unimpaired mean monthly natural flows mainly during the late fall to late spring when the reservoir is filling.

Peak flows as recorded near Gridley were in excess of 150,000 cfs in 1965, 1986 and 1997. Under these conditions overbank flooding is widespread. Lesser, but still significant floods have occurred in 12 of the last 42 years based on the Gridley gage.

The lower Feather River is also constrained by levees but in some locations, these are located at some distance from the channel. There are several areas where substantial riparian vegetation and/or orchards exist within levee boundaries. These are locations from which LWD is recruited into the stream from natural erosional processes or intentional placement by orchard operators.

The regulation of moderately-sized peak flows in the lower Feather River may affect natural recruitment of LWD from bank erosion. However, this does not seem to be reflected in LWD inventory data for the lower Feather River (see below). Data on bank erosion will be forthcoming from SP-G2. Observations in the field indicated several instances of LWD recruitment from both riparian vegetation and orchards in areas of bank erosion.

Bank protection in the lower Feather River has been evaluated under SP-G2. Above Yuba City, the most extensive area of rip-rap is located at Gridley (4,000-5,000 feet of stream bank). It presently protects the Gridley Bridge and other structures from bank erosion. Rip-rap is also located at Sunset Pumps. In some locations, presence of rip-rap is difficult to observe because of sediment deposition and vegetation. Below Yuba City, approximately 15 percent of the river bank is rip-rapped on both sides of the stream. Rip-rapped banks represent areas where LWD placement could enhance shelter and rearing habitat for salmonids.

The channel below Thermalito is highly variable in its geomorphology. It is about 59 river miles from Thermalito to the Sacramento confluence. The entire length is classed as Rosgen stream type F, entrenched. Substrate becomes increasingly finer downstream and is mostly sand from River Mile (RM) 39 down to RM 0 at the Sacramento River confluence. Reach sinuousity varies from low (straight channel) to high (at RM 34-35). The effects of levees, as well as resistant geologic formations (e.g., Modesto Formation – lenticular silt and clay lenses) are to reduce overbank flooding and meandering. The lower Feather is deeply incised into hydraulic mining debris (10-25 feet), which further disconnects it from its floodplain.

There are some locations where there is a relatively high diversity of instream geomorphic surfaces. For example, between RM 39-54 there are multiple islands, bars and side channels. These areas of topographic diversity represent places where existing or supplemental LWD could be particularly valuable for enhancement of fish habitat.

Under SP-G2 the occurrence of LWD in the lower Feather River has been mapped. Pieces larger than three inches diameter and three feet long were counted. Most pieces were twice that size. Larger pieces were up to 48 inches in diameter and 100 feet long.

The smaller pieces were in log and debris jams. Although the data are somewhat incomplete, the preliminary results are available. Attachment 1 shows the distribution of LWD pieces by channel position. Over 75 percent of the counted pieces between RM 0 and RM 59 were located on either the right or left bank. The small amount of wood associated with backwater or secondary channels is a reflection of the rarity of those geomorphic conditions in the lower Feather River. Where secondary channels or backwater exists, the amount of LWD is relatively high (see Attachment 3). Attachment 2 shows the number of LWD pieces recorded by river mile. Although the values are highly variable, there is an increased abundance of wood in the section of the river where sinuousity and geomorphic diversity are relatively high. Most of the wood observed was either cottonwood or orchard trees, with some oaks. Recruitment was from the outsides of meander bends or from straight sections of stream. The primary recruitment mechanism is bank erosion although some orchard trees have been intentionally placed in the river (i.e., dumping). LWD appears to have a long residence time in the lower Feather River, probably because of the controlled flow conditions.

As a further illustration of conditions in the lower Feather River, Attachment 3 is a map of LWD occurrence between RM 45 and RM 43. The accumulations at the entrance and exit to the backwater channel below RM 45 are notable. In this type of location on large rivers LWD can play an important role in providing shelter for fish during high flows. Between RM 44 and 43 (Attachment 3) where the stream is straight, most LWD is positioned at the banks. In that type of location LWD can reduce bank erosion and provide valuable rearing habitat and shelter for fish.

At flows in excess of 5,000 cfs most of the LWD in the lower Feather River is submerged and not visible. Consequently, the LWD survey underestimated the true loading. Follow-up field studies indicated that up to 50 percent of the LWD present might not be visible during higher flows. Even at lower flows, partially submerged near-bank and fully submerged mid-channel LWD is not visible.

Design Considerations and Evaluation:
In a river the size of the Feather, LWD placements would need to be strategically located if they are to have effective and sustainable results. Inventory information on LWD occurrence can be used to determine where wood has accumulated or persisted under the regulated flow regime. These locations tend to have high geomorphic diversity and high sinuosity. They would be candidates for enhancement with additional LWD, assuming that field evaluations indicated the potential for creating benefits with additional wood. The other sites that should be considered for LWD placement would include barren, rip-rapped banks. These areas provide little or no cover for fishes and may be in need of geomorphic function restoration as well.

To approach planning an LWD placement project for the Feather River the first step would be to identify suitable locations. The next step would be to examine the existing inventory data at those locations to determine if LWD is clearly deficient. The sites that are suitable and deficient should have the highest priority for treatment. It would be best to coordinate the selection of sites for LWD placement with other Resource Actions that seek to improve fisheries habitat.

Most LWD placement projects have been done in small to medium-sized streams, especially on the north coast of California. LWD placement has been done on the American and Sacramento Rivers in conjunction with bank protection projects. This has improved the habitat values of what would otherwise be barren, rip-rapped banks. In other larger rivers, such as the South Fork of the Eel River, LWD placement has involved logs extending from banks into the channel for creating local scour pool habitat or shelter.

For LWD structures to perform to their maximum potential, variable flows and sediment should be available. Wood works with variable flows and sediment to create habitats. For example, scour pools are created by the acceleration of flows during floods immediately downstream from a log structure. Neither variable flows nor abundant sediment are available in the Feather River under current management. Nevertheless, even in the absence of either variable flows or appropriately sized sediment, wood placement will create favorable habitat conditions for fish and other organisms (i.e., additional instream shelter). Many additional benefits could be achieved by coordinating planning for LWD placement with other measures proposing alternative flow management, creation of side channel habitats and replenishment of spawning gravels. For example, LWD placed at upstream riffle crests can be used to help retain supplemental gravels.

Generally, the size of logs used in a placement project should correspond to the size of the stream. Spanning LWD structures must be longer than the bankful width and at least 50 percent of the bankful depth in diameter. Using spanning LWD structures in the Feather River is not feasible given its width and the depth. Any placements on the Feather River, regardless of location, should be done with the largest material available, preferably with attached rootwads.

As a rule, LWD placements are usually done as single logs, groups of logs or combinations of logs and boulders that are commonly anchored or cabled together (Flosi et al. 1998). Anchoring would probably be required for any placement projects in the Feather River that are intended to provide site-specific benefits (e.g., enhancement of fish habitat on rip-rapped banks or enhancement of side channel habitat). Wood may be anchored at banks with cable or between natural or artificially placed rock. Logs are sometimes buried in banks as well to increase their stability. In side channels and backwater areas, clusters of logs and boulders joined together with cable would probably be the most stable structures.

Consideration could also be given to use of unanchored wood that would be redistributed by streamflow. However, use of unanchored wood might be less acceptable due to potential effects on navigability and public safety. One argument in favor of unanchored wood is that it would be redistributed throughout the system during peak flow events and end up at natural accumulation sites. However, transportation of LWD beyond the Feather River to the Sacramento River and Delta would still be obstructed by channel geomorphology and sediment deposits (e.g., sand bars near the confluence.

Some of the most promising opportunities for LWD placement are in backwater and side channel areas away from the thalweg. Mesohabitat maps of side channel and backwater habitats are currently available from SP-G2. Medium to high complexity LWD placements in these areas may enhance juvenile salmonid rearing habitat diversity and quality for the life of the placement (until the next high flow event) or until the break down of the material into lower complexity LWD. Existing inventory information indicates that many of these backwater and side channels already have high levels of LWD (see Attachments 1 and 3). There is also the potential that these backwater LWD placements would become refuges for predators of juvenile salmonids.

Under the current regulated flow regime, LWD placements will provide some level of benefits until the next peak flow event. When that occurs, the magnitude of flooding will redistribute both naturally recruited and placed LWD. This redistribution process should not be considered a design problem but rather an opportunity for the river to define itself. In the event that LWD moves out of the Feather River during extreme flow events it would provide benefits downstream, perhaps as far as the Delta.

There would be permitting requirements for LWD placements. These would include, at the minimum, 1601-1603 Streambed Alteration Agreements from the Department of Fish and Game, a 401 Certification from the State or Regional Water Quality Control Board and a 404 Permit from the US Army Corps of Engineers.

The way to evaluate the effectiveness of LWD placements is to: 1) monitor the placement itself and the habitats it creates; and 2) to monitor fish use of LWD structures and associated habitats. The latter, termed “validation monitoring” has recently gained wide recognition amongst fisheries biologists as the true test of restoration project effectiveness (Botkin et al. 2000). If unanchored wood is used, its movement through the system can be monitored with radiotelemetry.

Synergism and Conflicts:
LWD placement could create conflicts with land users adjacent to the channel if bank erosion is inadvertently increased due to flow deflection. There could be additional public safety concerns due to impaired navigability.

If LWD placements are coordinated with other measures for habitat improvement (e.g., gravel placement, side channel habitat creation) and flow management, there could be synergistic results. Conversely, implementing any of these actions independently of the others could cause conflicts.

Uncertainties:
There are uncertainties related to the experimental nature of LWD placements, in general. There are also uncertainties related to potential adverse effects on other resources. Some concern has been expressed regarding creation of habitat for predators of anadromous fish. Many uncertainties can be avoided by confining LWD placements to those locations where it can be reasonably expected to remain in place at least until the next extreme flood event. Monitoring of placement projects and their use by fish would also be advisable.

Cost Estimate:
The costs for implementing LWD placements vary tremendously. Costs are incurred due to equipment needs, construction materials, and for the wood itself (unless it is freely available). There are some potential sources of LWD, such as corralled LWD at Lake Oroville and flood bypasses. Lands adjacent to the river that are in agricultural uses represent a source of discarded orchard trees. Recent fires in the river corridor have also created sources of wood that could be exploited. The costs for moving this material to placement sites will be proportional to the distance involved. There could also be relatively high costs for gaining access to the river from the adjacent banks for heavy equipment. The third major expense would be for materials used to anchor or otherwise secure wood placements. In general, LWD placement would be less expensive than more intensive habitat creation proposals (e.g., creation of benches and side channels, levee setbacks, etc.). However, each such placement project will probably range in cost from $10,000 to $100,000, depending on its size, complexity and location.

Recommendations:
There are sufficient data available to do further evaluation of this measure. Existing geomorphic mapping, bank condition mapping and reach classification provide data on potential sites for LWD placement to enhance resource values. An inventory of LWD occurrence has been completed and the data from that study will be available by December 15, 2003. . Those two pieces of information can be used to develop at least a preliminary list of sites where LWD may be deficient in the system. From there, more site specific evaluations should be conducted. Site specific considerations include:

- Potential benefits (e.g., improved fish shelter)
- Potential impacts (e.g., bank erosion, impaired navigation, etc.)
- Potential stability of placement
- Costs and logistics (e.g., LWD supply)

Any site specific evaluation should be coordinated with the planning for other Resource Actions in the Feather River. For example, use of wood in conjunction with the creation of side channel habitat (EWG 16A), riparian enhancement measures (EWG-17 and EWG-51), and sediment recruitment/enhancement (EWG-18, EWG-92) should be considered.

If additional measures such as an altered flow regime or geomorphic restoration are ultimately approved for the Feather River, the role of LWD placements should be carefully evaluated. LWD placements may complement these measures or be rendered ineffective by them.

Literature Cited:

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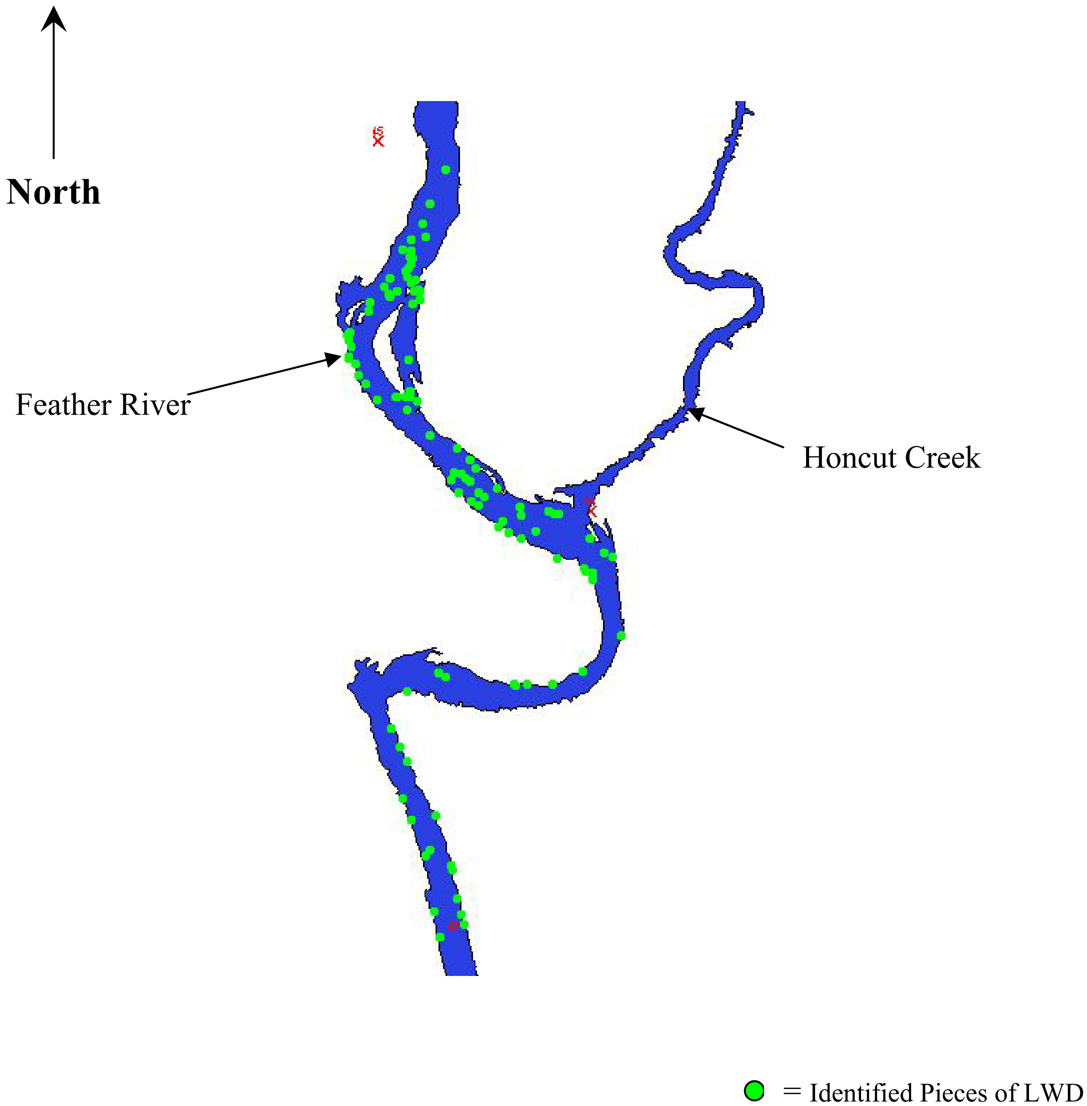

Figure 1. Distribution of LWD in the Lower Feather River (River Mile 43 to 45)